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ABSTRACT

A longitudinal study was conducted to examine how a person's concept of learning, teaching, and self as teacher and learner changes over the years, and to understand the factors which contribute to the development of teachers. This paper presents the stories of two teachers who participated in the study--Beth who taught middle school science classes in an environment that emphasized the learning of thinking processes, and Jim who taught secondary classes for which state-mandated exams focused on the recall of specific content. The research began when the participants were teacher education juniors at Cornell University (New York) in a program committed to student reflection, and followed them through their first 3 years of teaching. Data were gathered through in-depth interviews and classroom observations over the course of the 6 year association. The stories demonstrate that by the third year of teaching, Beth and Jim present very different figures influenced by contextual factors. It is further illustrated that both, now tenured, are still committed to teaching, have thought carefully about their teaching, have structured their teaching to serve the goals operating in the systems in which they teach, and continue to have ideals toward which they are striving. (Contains approximately 20 references.) (LL)

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TWO PATHWAYS TO SUCCESSFUL TEACHING

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TWO PATHWAYS TO SUCCESSFUL TEACHING

Introduction

For this poster presentation, I report on an on-going longitudinal study of teacher development by presenting the stories I have written about two of the teachers who are part of the study. The longitudinal study started when participants began taking courses in Cornell's Teacher Education in Science and Mathematics teacher education program as university juniors. In the TESM program we work to educate teachers who are knowledgable about their subject matter, aware of students' possible alternative conceptions, and committed to reflecting on their own teaching beliefs and practices. In this longitudinal studied I followed the two teachers through their first 3 years of teaching, and now have tenure in their respective school systems. The purposes of the study are to:

- examine how persons' conceptualizations of learning, teaching, and themselves as teachers and learners have changed over the years,
- to seek to understand aspects of their lives which contributed to their development as teachers.

As a teacher educator I am also, of course, concerned to speculate about how I can change my own practice, and the TESM program based on what I learn from these successful teachers. I've called these teachers successful because they are tenured, still committed to teaching, and have thought carefully about their teaching and structured it to serve the goals operating in the systems in which they teach. They continue to have ideals toward which they are striving.

Perspective

The longitudinal research has been conducted from an interpretivist perspective (Taylor, 1982), which assumes that any understanding of the events of another's life requires examination of the individual, the context in which he or she lives and his/her interpretations of the context. The research also incorporates what Harding refers to as feminist standpoint theory (Harding, 1990, 1991). I assume that I, as a researcher and outsider, may form a different interpretation of someone's reality. This interpretation will be shaped by my own perspective. I cannot, then hope to present an undistorted view of someone else's views. This belief has shaped the ways in which I have addressed, in the research reporting, my relations with the two teachers with whom I've worked. As Nespor and Barylske (1991) point out, in research interviews when teachers talk about themselves to researchers they are "not revealing but crafting and constructing, those 'selves'" (Nespor and Barylske, 1991, p. 811). So too, when I observe these new teachers or interact with them as professor, they are creating selves within a particular setting, framed by our roles, our histories together and separately. Thus my descriptions and analyses will reveal things about me, as my own standpoint in relation to them figures in the work. The degree to which any researcher can make her own subjectivities explicit is a matter of debate (see, for example, Peshkin, 1985 and 1988; Buchmann, 1992).

The research is related to the narrative inquiry described by Connelly and Clandinin (1985, 1986, 1988). I have set the themes of the stories told by the teachers in our conversations by the questions I have asked. I have sought to understand notions identified in the literature as important to teacher development as these notions were instantiated in the lives of the teachers with whom I talked. This research has also been strongly influenced by those who have rejected the technical-rational (Schoen, 1983) view of knowledge that had at one time dominated much of the research on teacher development and teacher thinking. The research reported on has been strongly influenced by the researchers who have sought to understand what can be called teachers' craft knowledge

(Clandinin, 1986; Elbaz, 1981; Elbaz, 1983; Calderhead, 1989; Grimmett and Mackinnon, 1992; Nespor and Barylske, 1991; Woods, 1987).

I have viewed teaching as a reflective activity (Grimmett and Erikson 1988) in which there should be a continual interaction between conceptualizations and actions. My longitudinal study has sought to determine the understandings or knowledge that is grounded in practice, in the particularities of daily life as they are influenced by the biography and history of the teacher. The focus is on the practice of these teachers; I am not attempting to fit them into a typology or develop lasting characterizations (Britzman, 1992). As Britzman's 1991 title says, practice makes practice. I have assumed that teachers' knowledge of practice, in practice, will develop and change over time and have sought to understand some of the ways in which that change occurs.

Methods and Data Source

The main data have been gathered in in-depth interviews done over the course of six years, starting when the teachers were juniors in a teacher education program. Students volunteered to participate in the study, and have always had the option to withdraw whenever they wished. While the pre-service teachers were undergraduates, the interviews were done by graduate student research assistants, both older and experienced teachers, both very capable. Once the teachers completed student teaching, which I supervised, I conducted all the interviews. When the teachers began their teaching jobs I visited their classrooms and observed before doing the interviews. Much of the interviewing, then, and all the analyses have been strongly influenced by my own knowledge of the teachers, gained through working with them as one of their professors and observing them teaching.

My extensive interactions with the teachers has meant that the process of developing the rapport needed for a good interview has already taken place. There are a range of shared experiences to which we can refer when having the interview conversations, and these shared experiences have facilitated understanding. However, the familiarity has also meant that I have had to be quite careful to make sure I have understood what people have meant. Teachers have reviewed every version of the analyses which I have presented, and have had the option to delete or amend any aspect. I find that they, and spouses and parents, have often read over reports to ensure they are acceptable.

Analyzing data gathered over six years presents a formidable challenge, particularly when one hopes to present a rich story about the course of a teacher's life. (Brown and Gilligan, 1992 explore some of these challenges evocatively). In the analyses, I identified major themes that related to my interests and were salient to each interviewee or across interviews. In this presentation I focus on three themes: notions of learning, notions of teaching, and notions of self as learner. I traced the ways these ideas became elaborated over the years, and looked for evidence of the complex interactions among these themes and the settings of practice that shaped the development of the themes. I have paid particular attention to things that surprised me, that were not what I would have expected. At the start of the study, I predicted that each of these two would be good teachers, and would teach in ways similar to each other. On the surface, though, in their third years of teaching they presented very different figures. These data are, necessarily, difficult to summarize in the style of research results. I will attempt to illustrate one interpretation. The posters show some of the evidence that lead me to this interpretation.

During the first three years of the study, while she was still a student, the female expressed much more self-doubt about her ability to figure things out in her subject matter. The male teacher regularly gained in confidence in his ability to figure out his subject matter. I expected, that as new teachers, the woman would experience more self-doubt and have more difficulty assuming a

position of authority in the classroom. In fact, neither reported having a difficult time accepting authority. The woman's self-doubts could be re-interpreted as a recognition of the negotiated and ofttimes serendipitous nature of meaning. Her epistemological stance seems to have contributed to her ability to develop classroom learning activities that were very open-ended and that allowed students to become engaged in many different ways. The man did not go through obvious self-doubt or questioning of his abilities to figure out subject matter. He developed a teaching approach that emphasized the standard curriculum knowledge. He has developed a course structure that helps students to make complex connections across the topics covered, and with topics outside the discipline.

These two developmental trajectories, however, were also strongly influenced by the contextual factors. The woman taught middle school science classes in an environment that emphasized the learning of thinking processes rather than the learning of specific content. The man taught secondary classes that had state-mandated exams that focused on the recall of specific content and worked in a school system that gave pupil performance on these exams tremendous salience.

Interview Selections and My Interpretations

In an attempt to portray the tentativeness of my interpretations, I've chosen an atypical format for presentation. I've listed selected quotes from Beth over the six years of our association, indicating which year the interview took place. The quotes I've selected illuminate conceptions about some key areas. I present all the quotes I selected, then follow with my musings. I follow the same order in presenting the quotes from Jim. The format may be confusing, but I wish to develop some way to engage you, the reader, in the interpreting. Should any of you wish to contribute your thoughts, please do write.

BETH

Learning

. As a junior, Beth recalled that she been scared when she first came to Cornell, unsure how she would compare to other students. She had spent a year after high school graduation as a student in France, and this experience was important to her. She recalled realizing one day there that she knew nothing and had lots to learn.

> *This idea that suddenly I knew absolutely nothing and there was so much over there I could learn, there wasn't a step I could take without seeing something brand new.*

During this junior year interview, Beth said that she felt that in high school she had liked to learn but had not been into academics. Before coming to Cornell, however, she realized that

> *what I learn here is what I learn and there's nobody else, so I have to do that for myself and it's not going to be handed to me on a silver plate for the rest of my life.* (Junior #1)

The important thing in introductory biology was not

> *these tiny batches you pick up from everybody [every professor] but when you go outside and look at a tree or something you have a better idea of how it works.*

Beth said that she'd realized she had learned a lot in introductory biology because in advanced biology classes *"I used a lot of things I learned in there."* (Junior #2)

Beth said it was important for students

> *that they leave their class with the feeling that they could learn it on their own now, that they could continue on their own, and that they have enough of a base to keep on learning.*

Beth then added a comment that parallels what she had said about her learning a year earlier, that :

> *they're gonna get from the class a lot of things they don't realize. I know that happens to me. Just things you start to use and you can't figure out where they came from.* (Senior #1)

During her senior interview, Beth discussed some of the clinical interviews she had done as a junior in a TESM course. Beth told Dentes that she'd noted that her interviewees had

> *all sort of different ideas about what heat did to molecules which, to me, seemed strange because that's a very basic concept. It seemed to me that students would realize that it just makes molecules move faster.*

Beth said that these interviews with non-science majors were

> *very interesting because they were very capable of figuring out what was going on but they just didn't realize it.* (Senior #2)

> *It's a wonderful feeling that I've been allowed to. . .been allowed to organize what* **you**, *what* ***we've*** *discussed in class.. **I've** been organizing what's important about those experiences for myself. Every once in a while I wonder about whether I've got something completely wrong (Laughs) , if I have a very messed up big picture. But since I don't figure anybody else has that great an idea on the big picture, it's not. . .(trails off)*
> *Everyone's mind works differently . And in different situations. So many of your ideas, or your organization of your ideas, seems to be coincidental. Sometimes . For me. A lot of times, something clicks in my brain, but it could very well click due to a haphazard experience.*

When I asked her how she could tell if a leaner really understood something, she replied quickly that she hadn't *figured that out yet.* After we both laughed, and she'd started to leave, she returned and mentioned that giving open-ended writing assignments did help determine how students understood things. (MAT #1)

Self as Learner

WHEN YOU SAY YOU DEFINITELY LEARNED SOMETHING, HOW DO YOU REALLY KNOW THAT?
Because I can tell from before the course how I would attack a problem and how after the course I would. (Junior #1)

Beth referred to a belief she felt was commonly held by students

that what you think isn't really worthwhile -- That's the way I felt as a learner and I don't know how you would convey that to a group of students, that what they know and what they're learning at that very instant is all they need to know to figure something out on their own. But for me I didn't realize, I didn't see where this tiny bit of knowledge fit in. (Senior #1)

Now, that sort of thing [figuring out three-dimensional changes in geology] I would have never even bothered trying to really do it. I would have tried memorizing the pattern.
SO LOOKING FOR THE ALGORITHM?
*Uh huh (yes) So that's been a big thing this semester, with physiology . Trying to figure out **why** I was doing that, not just because the other problem is done the same way. J. doesn't get through his assignments nearly as quickly as I do (I laugh). But. . . He figures them **out**. Because that sort of thing is intriguing to him, it's not nearly as traumatic, to him. So I think I've learned a lot from working with him.*

I asked her whether she had thought, when she was looking for the algorithms, that she was doing her best.

*I thought I was doing the best job possible, yes, But I didn't think I was getting it. 'Cause I put in the time, but I put in repetitive time. For some people it takes only once, but they go through it slowly and if they look at this chunk and it doesn't **quite**, if they can't quite figure out where the author derived the equation, they'll go look it up someplace else in the book. And **that** is a fascinating concept to me (we laugh) A bit new!! Where as before I was saying, "Yeah, I think I see, I must have covered that. So, I thought I was doing the best job I could do, but I really wasn't. I wasn't taking it into my own hands. To figure out what was going on. HM Out of fear and disinterest. UH HUH*
WAS IT FEAR OF FAILURE?
Fear that when I turned to that other page it was going to look just as wild as this first page. (we both laugh) (MAT #1)

DO YOU THINK THAT, THAT THEIR LEARNING WOULD BE EQUALLY IMPORTANT IF THEY CAME UP WITH SOME OF THE WRONG UNDERSTANDINGS.
*Sure, I think they do. And I probably taught them incorrectly. Because, again, [she's laughing] it's really, for me, it's very much exposure. Because a lot of times, if you get an exposure, it's when you get it a second time. it's when you come up on it , on your **own**, when you're not in a classroom, when you happen to pick up an article, when you happen to see it on TV, it's that second time around when you weren't in a classroom, that makes it interesting. So you listen to it, and say, "Oh yeah, now I'm going to remember. I want to learn it." so I really feel a lot of times I'm just exposing them so they'll be interested when it comes up again.* (Third Year #1)

Teaching

As a junior many of Beth's ideas about good teaching seemed to reflect things that had not occurred in her initial biology courses - a good atmosphere without tension and competition, where the teacher had a personality that elicited student talk and interaction.She couldn't identify specific factors that validated her learning but speculated *Maybe it came from talking with the T.A.'s, one on one. And having them listen to you.* (Junior #1)

As a senior Beth did field work with a middle school teacher who practiced conceptual change teaching and who therefore worked hard at providing opportunities for students to develop and express their understandings. At least some of Beth's notions about good teaching seem to have been influenced by her experiences working with this teacher. When interviewed by Dentes her senior year, Beth felt that teachers should not tell students the accepted science explanations, should not correct students' ideas but present the current orthodox views as alternative explanations. She thought teachers should help students trust their own ability to figure things out. When she described her field experience she said that

> *I would never have seen... now I've seen how much fun it is, and how good it is for the person, to let them explain it to themselves. We played with that* (concept) *for about an hour and the students got closer and closer. But, actually, that concept they never hit. But some concepts they do come up with on their own, they do figure out.* (Senior #1)

When interviewed at the end of the TESM program Beth noted that her ideas about what was necessary for good teaching had changed greatly during her three year tenure in the program. As she described this she said:

> *It's very difficult to think, because I don't know where to start. Because my entire attit, not just factual knowledge, but attitudes have changed completely and I don't know really when it happened, where it happened, and*
> *WE USUALLY DON'T*
> *Yeah. Nobody will know when it started*
> *WHAT, WHEN YOU SAY ATTITUDE, WHAT DO YOU MEAN? CAN YOU GIVE ME SOME FORINSTANCES?*
> *Yeah. I think when I started the program a lot of things struck me as being bogus. HM WONDERFUL TERM.*
> *Um, because it didn't seem to be hitting at what was out there. I was coming in with the attitude of, "I've been working with underprivileged children for a long time," and I was coming in very much with the idea that what you needed was interesting motivational techniques.*

She had initially felt, she elaborated,

> *that the most important thing was the fact that you could communicate with your students. That they liked you... I figured teaching was a lot that you could ride on your own personality.*

She noted that after a semester and a half in the TESM program she figured out there was more to teaching than that. Now she was frustrated with friends who couldn't understand why she found teaching so fascinating.

> *How can I explain to them that what's so fascinating about it, it takes years and years and years to even begin to have an idea how best to teach a subject and with each student it changes.* (MAT #1)

She recalled her work with the middle school teacher when she described some aspects of her high school student teaching.

And I still every once in a while get a real kick, and I'm just ***shocked*** *that they got that particular idea out of the lesson I gave. I can't believe it sometimes. But, it's not, it's more interesting to me now than just what are they doing wrong. AH* (MAT #2)

One object (of the lesson I observed) was to get them to look through the books. Well, there were I think three objects. One was reading plaques when I take them to the zoo Thursday, I've found, with these kids, their mentality is, if they've done it their way once, and then they see someone else's way, especially like an adult way, they'll immediately compare and usually criticize. But at least they're reading and they're interested in reading plaques.

The other thing I wanted was, uhm. . just to expose them to some other animals before we get to the zoo. I want them to be able to look through the book and get the information. (Second Year #1)

They know ***exactly*** *what's going to be on the test, cause I want them to know that stuff so they might as well know it's going to be one the test.*
WHEN YOU, UM I WANT TO ASK ABOUT THE TESTS. WHAT KIND OF TESTS ARE YOU GIVING THEM?
Well, I'm doing several different kinds. HM Whatever. [she laughs] We had a test this time, it was a partner test. And it was all based on reading an article UH HUH and it was, and the first part was written and very other partner had to write and then the second part, the second day, was a lab on how well they could figure out how to do this lab with these balloons and um, clay, and it was all modeling rockets and satellites. HAH So that's one of them. I'm doing tests that have a hands-on assessment where they have to come back and they have to do something in lab, or they have to do something.. I also do tests where I, I just redo a demo or two demos that I've already done, and we've already discussed. And then they are to write and discuss again. AH. Almost all my tests are strictly, are essay, (Third Year #1)

WHAT DO YOU THINK THE MOST IMPORTANT LEARNINGS ARE THAT THESE EIGHTH GRADERS SHOULD BE GETTING OUT OF THE PHYSICAL SCIENCE? ..AND I CAN GIVE YOU SOME OPTIONS TO CHOOSE FROM IF YOU WANT.
Do you want to lead me? [she laughs - sounds tired.]
IS IT PARTICULAR CONTENT YOU WANT THEM TO GET, IS IT PROCESSES OF THINKING ABOUT SCIENCE, IS IT A BLEND OF BOTH, hm DO YOU WORRY ABOUT THEIR SOCIAL DEVELOPMENT? UM..
Okay, For ***them****, I want them to not just accept things the way they are. I want them to realize that there's more to it than meets the eye. UH HUH So, . I want them to have experiences here, and at home with their take-home labs, that later on, when they experience them again, other places, or daily, cause some of the things they do daily, YEAH they think about some of the concepts behind it. HM. And not even that they know the exact concepts, but that they know there is one. UH HUH. "Oh yeah, there' s a reason why this is a pattern." I like them while there here to know what that reason is, YEAH but once they leave me, they probably aren't going to remember, so I just want them to remember that "Oh, yeah, there is a reason for this. There is some sort of thing behind this, there's a theory behind this."* (Third Year #2)

Deb's Musing on Beth's notions of learning

As a junior, Beth spoke with some excitment and awe about how much there was to learn, and realized that learning new things would change the way one saw the world.

As I read her Senior segments over, it seemed that Beth had forgotten how much her view of the world had changed, had not fully realized how much she was taking much of her own science knowledge, what Hawkins would call elementary ideas (Hawkins, 1985) for granted. Knowing the effects of heat on molecules was a basic and obvious notion for Beth, but not for her interviewees. She was surprised at her interviewees' responses, but I can't be sure, now, how much she examined that surprise. I realize that I did not pick up on this point earlier because it was still becoming clear to me. I think this tension is one of the classical ones that inform discussion of hands-on or constructivist or discovery learning. Over the life of teaching the course in which students do clinical interviews, I've become far more aware of the difficulty represented by Beth's remarks. I may even, as I think back to my teaching, have contributed to her stance.

I have tried to let students explore their own understandings of science as they conduct and analyze interviews with others. I have tried to shift future teachers' focus from science content to the ways in which others conceive of this content. The result may be that by moving the focus, I have not helped students to surface the understandings they have developed as science majors. Beth and many pre-service teachers I've worked with have not been aware of the abstract concepts they used and regard as basic or elementary or self-evident ways of interpreting the world. Hawkins (1985) has made clear the difficulties in learning these elementary ideas, and the pivotal role they play in grasping the abstract frameworks of science. Based on my work with teachers, and my examination of my own practice, I can see how teachers' inability to realize the degree to which elementary notions from science have shaped their thinking contributes to some poor teaching and to their inability to grasp the reasons for student difficulties.

As a junior, Beth contrasted learning details to gaining an overall sense of how things work (Junior #2). As a senior, however she did not set up the same dichotomy. (Senior #1, and #2). She contrasted learning details to developing a sense of efficacy, and considered that developing a sense of efficacy was more important. A sense of efficacy as she saw it, was not separate from content learning, but went beyond merely learning content.

Deb's Musing on Beth's notions of herself as a learner

Our interviews provide evidence to suggest that Beth's understanding of her own learning evolved during her time at Cornell, and it appears that much of her development involved her efforts to attain her goal of being a self-directed learner. Although Beth reported beginning her studies at Cornell with the commitment to do the work for herself, her awareness of what was entailed developed.

Beth's statement, in her MAT interview, about her earlier beliefs hints that she may have been a somewhat passive learner. There are two things that contribute to my speculation. One is the sense I get from the quote above, that content sometimes didn't fit into any big picture for her. The other hint involves a stance toward authority. Beth noted it was hard to help learners not just to accept what the teacher said because *"teachers are the authority figures and you know you should accept it that way,"* Beth thought it was hard to give students the

ability to ask themselves, and others, questions and I wonder if such questioning had once been difficult for her, if it continued to be difficult. (See also Learning, MAT #1).

Deb's Musing on Beth's notions of teaching

The MAT #1 and #2 quotes, and others, illustrate that by her last year in the program Beth voiced what can be a daunting realization, daunting at least to those who want to find the infallible techniques, the guaranteed methods for teaching. She seemed to acknowledge the ambiguity of teaching and own her ability to make sense of it for herself. This next quote shows how her thinking about learning embraced the lack of certainty we face as teachers. In this masters' year interview Beth said she had come to realize the lack of certainty that pervades teaching, without despairing.

One of the distinctions that I hear frequently is that between teachers who describe themselves as teaching a particular subject and those who describe themselves as teaching youngsters. Beth would seem to be one of the later, but in a way that included learning biology content. In her MAT interview she observed of her fellow students

Every body else is talking about teaching this concept, that concept. For me, I think the most important thing is to get people interested, because I think that enriches your life.

In my own talking about biology teaching, I have had to remind myself of this view, one which I think is superior. It is so easy for many of us science educators to carry on about what students must know in order to be scientifically literate or informed citizens or able to care for their bodies. The energy in such a position can quickly lead to statements about essential knowledge and to a forgetting of the lives of the learners and an honoring of their goals and interests.

These extended quotes from her second and third year of teaching reveal, I hope, Beth's continued commitment to creating situations to engage learners. Also, she shows her strong concern to relate science to other disciplines, and to help students to integrate science material across units. She might, for example, have prepared students for the coming field trip by giving them a list of questions they had to read plaques to answer. Or she might have given them an assignment to find as many somethings as they could. Instead, she involved them in the designing and presenting of their own plaques, in the hopes that the experience would help them better evaluate what they saw at the zoo. (Second Year #1)

JIM

Learning

Kerr asked Jim about a powerful learning experience he recalled from biology.

Well I remember in my first semester of intro bio it convinced me that I liked it, that biology was what I really wanted to do. I think just knowing how things work, some anatomy and actually the muscle system, how they work . And I remember looking at my hand and saying "Wow, I know what happens when I do this and exactly what is going on,." I think that was probably something I remember.

WHY DID THAT GRAB YOU?

I'm not sure, I guess just you take for granted simple things you do everyday and yet people have no idea of what goes on and all of a sudden you ask the question like when you were small and all of a sudden you know how and you don't take it for granted as much as you used to. (Junior #1)

As a senior , when Jim talked with Dentes about the same introductory course, he reflected more on how he had changed. He referred to taking the course as a freshman when he just worried about getting through the course and the material, with little thought about how things fit together. As a senior he felt as though his work in the introductory class and the advanced courses he took, had helped him to relate things, to see how things in biology fit together. He referred to this course in the MAT interview:

Going through the material a second time, ...reinforced a lot of the concepts and basic ideas of biology for me....Just going back to the first year, you know, the things seem to, to mold together and put together a lot stronger and a lot better. 'and now I see like Unit 1 through 10, now I see how they fit together, whereas when I was a freshman taking the course it was like "Okay, I've got to get through Unit 1, do the work for unit 1, cram it all in." ...When you got to teach it, you could definitely see the flow, I guess you'd call it. The flow of one unit to the next. (MAT # 1)

In the semester after student teaching the curriculum course Jim took required him to analyze a curriculum. He analyzed the BSCS curriculum, which presented science as not just a body of fact, but

as a thinking process where people ask questions and then gather information in order to see if they can answer that question with the information. And that science isn't static, it's dynamic and keeps on going. (MAT #2)

During his last year in the program I asked Jim how he told if students understood. After student teaching, he noted that telling when students understood was hard, but did observe that students usually got excited when something clicked with them, and they could ask question that were relevant and appropriate for that idea. You could tell from their written work and homework, though

You don't always know if they really understand it or not because it could be coming, reading a book, "Okay let's see, you've just got to put some words down that make sense here." But usually, I mean, if you design questions that which sort of make student put together several different things from different parts of the book then, I think it, the linkages which, if they make the correct linkages is sort of, is a key. You can seen if they really understand what's going on. and if they can go back to some underlying principles like diffusion or something like that. (MAT #3)

Self as Learner

Kerr asked Jim how he knew that he understood things in the introductory biology class:

You had a schedule - a unit about every week to 10 days. And they would give you a number of pages to read and answer questions in the manual and assess whether you knew it or not. There would be an oral exam with a TA [and you would] sit down one on one with the TA and they would ask questions and reply with the answer. And they wold also ask questions that would sort of tie in some information from other units. And just to keep up on what you have learned already and what you should and learning. And it was pretty good. If you actually didn't quite understand how something worked, and partial parts of how it did, you wold sort of go through it with a TA during the exam. And they would lead you into the answer and a lot of times it would be quick, [that you'd learn it] right during the test. I liked that a lot - I felt that was a lot better than a written exam because on a written exam you end of guessing, ... and the teacher cannot really see how yo got the answer and if you understand anything of it. They can see if you understand some of it, or what is getting you into trouble. (Junior #1)

During his senior year interview with Dentes, Jim commented on how he felt that he learned. As a learner,

I think I'm a better listener than I am anything. For discussions and things like that, I tend to be more on the quiet side instead , listening to what other people have to say...I feel that I have to get a little perspective from everybody...What I initially think probably won't be a good idea because I still haven't I haven't considered what other people have said....As a leaner I'm better at assimilating other peoples' thought and ideas and then, than afterwards, like when I'm walking home forn the class I'll think about something I should have said, I could say now. (Senior #1)

Jim's consideration of the importance of the structure of biology is evident in his description of himself as a learner in his MAT year, after student teaching.

HOW WOULD YOU DESCRIBE YOURSELF AS A LEARNER, NOW?

Again, trying to fit things into. what's there already. And relating them to what's there already, Again, requiring examples .. which can be used for me to relate one thing to the next. [As in] biology. I'm trying to relate why a kidney does this and that. I think about diffusion again, or something. And you know, what this drug does. Okay, it's going to block so and so, so that way diffusion can't take place. As a learner now I'm sort of taking, you know, listen to what the Professor's saying and trying to say, "Okay, how does that fit with what I have already. And does that makes sense? Okay, now I see this, and I understand this part and this part. And this does this so you don't do this," It's sort of a cascade often, I think. It just leads to more and more things and different situations So as a learner, again, just assimilating that into what's in here and if it doesn't make sense, that I can't do that, then try to you know follow up and figure out why it's not fitting or what piece am I missing or what's not quite right inside here or why can't I make the connection.

SO WHEN YOU'RE TRYING TO UNDERSTAND SOMETHING, IF YOU CAN'T FIGURE OUT THE WHOLE PICTURE, IT DOESN'T' T MAKE SENSE TO YOU?

Right (MAT #1)

Teaching

During his junior year, Jim identified organizational aspects that contributed to what he considered good teaching (See Learning, Junior #1).

During his senior year interview Jim identified a number of criteria that would identify good teaching practices. Good teaching should help students put things together and extract principles or common properties. He felt it was important to develop memorable demonstrations that illustrate one or two principles, to use of student discussion about demonstrations that required them to explain what they think (in part because he learns well listening to and participating in discussion), to use of classical examples that help students relate class learning to events outside the classroom. For example, he cited an example from his work in sixth grade:

> *I think it's important to find examples that they're familiar with. 'Cause they, they know that you put styrofoam between - around a cup and that'll hold the heat in , the styrofoam cups for coffee. Or, if you hold a metal cup and pour hot water in it, you're gonna burn your hand. So, use some examples like that.* (Senior #1)

As a senior, Jim continued to feel that oral exams were an excellent technique to assess student learning, although he wasn't sure they would be practical in many settings. His responses assume some concern that an examination detect how students are thinking, rather than recalling terms. His other references to oral exams seem to focus on the chance to learn during the process, and the decreased concern with recall of vocabulary.

> *I don't know how you could actually do that for a high school class or, something like that, but, things where the students are asked more to explain what they think, honestly, as opposed to what I tell them or what the terms actually mean.* (Senior #2)

After student teaching, Jim felt it was important to be flexible as a teacher.

flexible in the sense where I'm always trying to think of those underlying examples which are always there and . . and present them in numerous different ways. Maybe that's not a very good example cause it sort of underlies a lot of things but. I guess just realizing that most everything is going to underlie . and relate to other things. Thinking about as many connections as you can and presenting them to students so that they say, "'Ah, aha, so that's why this does this and that and the other thing! " (MAT #1)

When I visited in his second year, Jim talked a bit about problems he had had in his first year using essay questions on exams and trying to use ways to asses student learning other than multiple choice tests. I didn't follow up much during those interviews, but focused on understanding his current course organization. As a new teacher, the school district he joined was committed to implementing the New York State endorsed Outcomes Based Instruction. Jim described how this OBI approach shaped his classroom practices.

> *We do retests in here, and I divide the tests up into sections so that, there's five questions for each section. If you get an 80 or 100 on either section, you don't you have to redo that section.*
> *OH, MASTERY GRADING.*
> *Yeah. Mastery. . learning. And that old outcome-based instruction. YEAH. I've never really bothered writing the outcomes for the class. But the tests are divided into outcomes. Like outcome one this last test we had was energy transfer. So I have five questions dealing with that information. And they have to get 4 of the 5 right or they have to retest.*

And usually by the second time most kids are retesting about 80. If they score 60, you know, I don't give them a zero in general biology class if they don't reach the 80, because some of them never make it through. But I do require that they have to take the test again if the don't get an 80 on it the first time. So they're into that mode. And in between they do some problem sets dealing with just that section. And they can retake any section they want. If they have an 80 and want to try for 100, they can do that, and take the higher grade. (Second Year #1)

I asked Jim about how his course was organized, and he pulled out the notebook in which he'd arranged all his materials, at least for this unit.

I have three or four of these notebooks. This is actually Regents biology notes, but I use the same notes for my general biology and I'll just delete certain things when we're going over them.

Like today I didn't care if they knew the names [of certain structures such as glomerulus but it was important for them to realize that the kidneys are made up of these little tubes called nephrons and they they are going to filter and take back some things. This is like typical notes that we'll do. For Regents biology we have our diagram page, and we do labeling diagrams a lot. I wouldn't use this for the general. The packet they have is more simple. Diagram type things.

But here'd be an example of a test. Answer key, divided into however many sections we had. And then divide the test up like that. Five multiple choice questions. I've done exclusively multiple choice this year. Because basically I'm getting, "Okay Regents is important, we've got to get these people" [to pass the test]. I mean from administration. That game, that game. YEAH YOU ONLY HAD 75% PASS LAST YEAR. Exactly. That's .. "Make sure you've got a little more this year. etc etc." And, the ninth grade earth science teacher, that was the format he did, and he's the science coordinator. So this is me playing the game, actually. For the time being. SURE. So this is the format. (Second Year #2)

When I visited him in his third year of teaching Jim was continuing to use Outcome Based instruction.

They're still big on this OBI, Outcome based instruction. This sheet is an example of. And other teachers don't do this, but I came out with these sheets for the kids. Because I found that, last year students just didn't have very many organizational skills as far as taking notes. And I wanted to streamline the note-taking process so I could spend more time doing other things. So I could use some class time for labs, eventually. And so I just came up with these lecture type sheets, which are skeleton outlines and you go along with the overhead, I stop and like you said explain things and um Like tomorrow I'll start the class and we'll do a 10 minute review like," Okay take out a piece of paper and let's think about what we did yesterday." UH HUM We'll do that type of things. And we'll get through the notes, and have some discussion and do some worksheets and do some problem-solving with it. And then we have our test and things like that.

THEY CERTAINLY SEEM TO BE TAKING NOTES ASSIDUOUSLY.

Yeah, Um this year I've got a really good group this year and and all but two students passed the midterm. The midterm, I thought, was pretty thorough, on what we covered so far. So that was encouraging. HM I think one reason is because they have everything, it's right there, and there have it and they're more organized than some of the kids were last year. Cause last year I worked with the overhead, but I didn't, they put it on their own piece of paper. And who knows where it ended up. YEAH. So this year, I'm trying this.

And I have all the diagrams in here, and everything is specific, then again with the outcome based, things that are on the bottom lead to outcomes. And I'm getting better, I think, I'm getting more organized and more efficient in doing things so I can leave more time towards the end of the year to like go spend a week out, in the woods. Cause I want to incorporate some of the things that we did this summer, UH HM for the Environment and Computing YEAH workshop. I want to take a whole week and just in class, use the week as a lab for ecology so I'm trying to speed through some of the note taking process this year. Getting through the notes, and I"m doing that. (Third Year #1)

I commented on the ease with which he referred to the material in his lectures, since he could recall just when they had studied some material, review what they did with it then, related it to what they were now doing, and on occasion referred to work they would soon be doing. I told him he appeared very comfortable, that he really seemed to be getting a handle on the curriculum, and could move around in it. He agreed, and said,

Like if I had my eyes closed in this rom I can sort of move around it with no problem and sort of pick and choose. Yeah, I fee la lot more .. I know what's there, I know what' s going to be,, what's going to be there, and I can draw some examples, pull from out. I try to do as much pulling from the outside that I can, just with examples that I can use that they can understand. (Third Year #2)

I felt able to push Jim a bit more in our third year interview, perhaps because of his increased confidence, and spoke a bit more explicitly about his traditionalism. The driving force, he acknowledged, was the Regents exam, and helping students to pass that.

I mean right now the testing is in the mode of preparing for the Regents. The stress here is the kids have to do better on the Regents YEAH on that type of thing.

I think, given the system we're in now and we're told that we have to cover this information, YEAH it seems like it. because, just of the system. What does the administration look for? During the first three year,s your tenure years. What are the Regents results, how did kids do on the test. So, and automatically, what type of test are we talking about;here. okay multiple choice state tests and all the right answers facts. okay, let's get the kids good at doing that. And once we et the kids get good at doing that for a couple years, okay we're deemed a good teacher, you'll stay here, YEAH and then go on. Like that. so the first couple years, like I said last year, playing the game, YEAH YEAH going the along just the.
WHAT KIND OF PERSONAL COST IS THERE TO THAT? HAVE YOU FELT ANY PERSONAL COST?
Yeah. I . I like the information we teach, I don't necessarily, I don't like being bound into having to teach the kids in this methodical way YEAH but I have to I realize I have to do that first UH HUM um . sometimes I feel guilty about doing it, like saying, "Geeze I know, they have to know it and the way I do it I know I teach them how to know it, but, then I take a look and wonder, because what are they really getting out of the course? And it's not a lot. So how do we make that transition from that into doing some of the same stuff but still learning more on top of that, and putting that together. So that's where I"m at now. Cause I think, I'll be here next year, I have no worry about that. (Third Year #3)

Deb's Musings on Jim's notions of learning

Jim seems to consistently view learning as the ability to make connections, to synthesize material covered in different areas (whether textbook chapters in a high school class or different biology courses in college) to come up with a detailed understanding of the processes studied. His view of learning is grounded in the content, with the added realization that learning new material could change one's perceptions of the world (Junior #1, Senior, MAT # 1, MAT #2, MAT # 1 from Self as Learner).

He learned, in his post-student teaching curriculum class, for the first time, that there was a developed curriculum that emphasized the process side of science. This one example has been enough for me to consider the curriculum class a significant part of the TESM program. We had either goofed by omitting consideration of the processes of science in earlier TESM classes, or not emphasizing different approaches to biology teaching in ways that registered with students. (MAT #2)

The influence of Jim's introductory biology course with the audiotutorial format seems quite strong in many of Jim's quotes. The course was not only AT, but all the exams given were all oral exams given by the teaching assistants. As the above quotes illustrate, the course helped Jim to learn to work consistently, and the exam format provided an arena for individual interaction with a teaching assistant and the possibility of with further learning, an arena not often provided to college freshman.

By the MAT year Jim is beginning to grapple with the uncertainties of teaching, as he reflected on how one could tell if students understand. Again, tho, he emphasizes linking of concepts as key to understanding. I cannot argue with this idea, but wonder if underlying this belief is a conception of the content of any biology as relatively static. (MAT # 3).

Deb's Musings on Jim's notions of self as learner

As a junior, Jim described his monitoring of his own learning in terms that were quite specific to the introductory biology class he had taken, and in which he was to be an assistant twice. His answer also revealed what was a fairly consistent image of the ideal testing situation, one in which there was one to one interaction with a teacher and one that would allow learning. There is also no reference to much self-monitoring in his learning. (Junior #1)

As a senior, Jim continues to talk about the external factors important to his learning and to avoid mention of any internal cues he might have about his learning (Senior # 1)

I had specifically asked him to describe himself as a learner when I interviewed him after student teaching, and he was very articulate about how he went through figuring things out. This awareness seems facilitated by his growing awareness of the structure of biology. He also, at this time, was articulate about the processes by which he monitored his own understanding. Jim uses created dialogue to illustrate his points, a move that I find often in more experienced teachers. He still has a strong belief that everything will fall into place when he understands, that there will be no ambiguity or uncertainty. (MAT # 1)

Deb's Musings on Jim's notions of Teaching

Jim's views of learning and teaching from his junior and senior years have a heavy focus on procedures that provide external feedback. We can see the importance he gives to student/teacher dialogue. In his MAT #1 quote, Jim also elaborates the teacher's responsibility

to organize content to facilitate learning.

His work in Outcomes Based Instruction involves a heavy emphasis on procedures, and Jim developed careful ways to implement this approach. As I reviewed our discussion during his second year of teaching, I realized that Jim was probably more aware of playing the game than I had initially thought. I think I was influenced by my own experiences in using competency-based education. I had come to reject it as a way to organize instruction, and was concerned that I not appear to dismiss the work Jim was doing on curriculum organization. I was also trying, I think, to hide my frustrations with the ethos that seems to characterize the education department of New York State, the search for an infallible technological solution to educational issues. Then too, I had come to conclude that I learned a great deal from my efforts to implement similar technological solutions, including writing behavioral objectives and designing CBE courses. So perhaps it was my ambivalence about the value of the work Jim was doing that kept me quiet during the interview and blinded me to his sense of playing the game. (Second Year)

Although Jim was, as he put it, playing the game by using OBI, learning to structure his course in the way valued by the school and in a way that would help students pass the Regents examination. I think also, though, Jim was working at understanding the curriculum that he was teaching, and learning about his students. He was working hard at identifying reasonable outcomes for the course, and relating these to unit and lesson outcomes. As far as I could tell, the outcomes were closely related to content and did not include attention to students' ways of thinking. I saw no material that addresses outcomes such learning how to analyze data in tables to support or refute a hypothesis about those data. I believe that this is a fault of the OBI system. Also, though , Jim's abiding commitment to helping students develop ways to synthesize their learning and make connections provided a fertile ground for his work on OBI.

I believe, also, that Jim's extended work in the AT introductory biology class provided him with a grounding that justified and validated his system of testing, the system used in OBI. The AT class did have mastery learning, although the tests were the oral exams that Jim favored. Jim has not figured out a way to provide these oral exams in his teaching, but the use of the correctives, part of OBI, do provide students the chance to review material in class when he is available to help. I think Jim had taken the OBI system and used it to institute what he recalled as positive aspects of the Cornell course. As I've noted, I didn't not push Jim nor did I share some of my concerns about OBI with him during our interviews the second year of teaching. I did explore these issues more in his third year of work.

His further ease with the curriculum (Third Year #2) makes me wonder about just how long it can take to reach this ease. I also realize that there really is no such thing as "introductory biology," because each instantiation will be shaped by the experiences and expectations of all the stakeholders. Pre-service teachers' experiences with introductory biology courses can only partially prepare them for the work they have to do to make sense of the course they will teach.

In his third year, Jim has played the game well and been successful; as a teacher educator, though, I worry that we at Cornell failed him in some way? He is not satisfied with what he is doing, but when he tried new techniques in his first year they did not work well. Did we fail to make clear just how difficult change would be? Did we forget how powerful the image of a college course perceived as good would be? Can we prepare graduates to succeed in traditional schools without being seduced by the compelling logic of such systems as OBI? Or, do new teachers find the help they need in OBI?

Conclusions

As all of us in teacher education know, or should know, our work in pre-service education is only the beginning of the education of the teacher. The conditions of practice will have a profound effect on the teacher's continued development. Although we might hope to education new teachers who will be nontraditional, who will teach in ways that we believe are better, new teachers must survive in an existing system. We can, I think, urge students to teach in settings that seem to allow more freedom. These two tales illustrate some of the differences between high school teaching in a state with an end of the year test and junior high school teaching in a state with no mandated testing. Having achieved apparent success, I believe that both teachers will continue to seek ways to reach their ideals. Jim's emphasis on content, occasioned as it was by the conditions of his practice, also has enabled him to develop a complex and fluid understanding of the course he's taught three years. His comfort with the content, couple with his continue dissatisfaction with the "game" he's played render him able to think about other ways to organize testing and assignments, other ways to conceptualize course goals. Beth, on the other hand, has experimented with a wide range of assignments and tests, and could begin to gather a collection of successful exercises. She has tried a number of things, and can now begin to evaluate more systematically those that she finds best for her students and her classes.

As a teacher educator, I wonder where our responsibility to our students ends. How can we better continue our efforts at teacher education so that graduates, whom we have influenced, can continue to learn from us and teach us?

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